Prepared for

CAPITAL CITY DEVELOPMENT CORP

PARKING STRUCTURE

July 2019

Design Guidelines

Kimley»Horn

Expect More. Experience Better.

PARKING STRUCTURE DESIGN GUIDELINES

Table of Contents

Introduction

This document has been developed for the Capital City Development Corporation as a guide for future parking structure design in Downtown Boise. It contains information to help developers and designers incorporate parking structure components into proposed projects. The concepts presented will help produce functional, well-designed and patron friendly parking structures that will become valued infrastructure elements for the Downtown. The concepts are presented so that common design mistakes can be avoided by being addressed early in the design process. The document is based on internal *Guidelines for Functional Parking Design* and should be periodically updated to reflect state-of-the-art parking design practices and principles. It includes the following categories:

- Design Review
- Project Delivery
- Sustainable Design
- Adaptive Reuse
- Site Requirements
- Site Constraints
- Concept Design
- Circulation and Ramping
- Access Design
- Parking Geometrics
- Parking Layout Efficiency
- Pedestrian Requirements
- Accessible Parking Requirements
- Safety and Security
- Lighting
- Signage and Wayfinding
- Drainage
- Fire Protection
- Open or Enclosed Parking Structure
- Structural Systems
- Durability Design
- Maintenance
- Other Considerations

In any future parking development project, it is highly recommended that qualified parking structure design specialty firm be engaged in the project due to the unique characteristics and design expertise required to develop a successful project.

Design Review

No matter the construction procurement/design option selected, the design team or developer should keep the City and Capital City Development Corporation (CCDC) informed regarding the design progress through submission of progress plans and supporting documents such as technical specifications at the completion of Programming, Schematic Design, Design Development, Pre-Final Design, and Final Design phases. Proper time for approval of drawings from the City, CCDC, and Parking Operator should be allocated prior to proceeding to subsequent design phases. The design team should reconcile all comments provided by the City, CCDC or Parking Operator.

Testing should be conducted of new parking access and revenue control equipment to ensure it meets vendor specifications prior to the completion of installation.

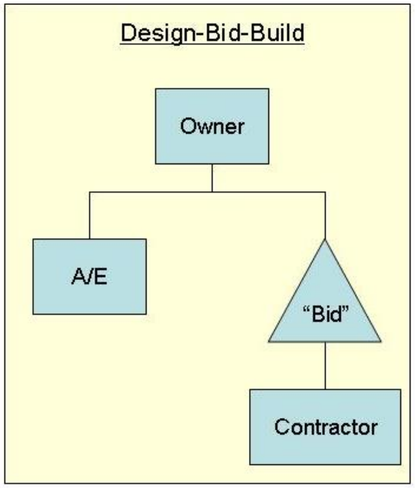
Project Delivery

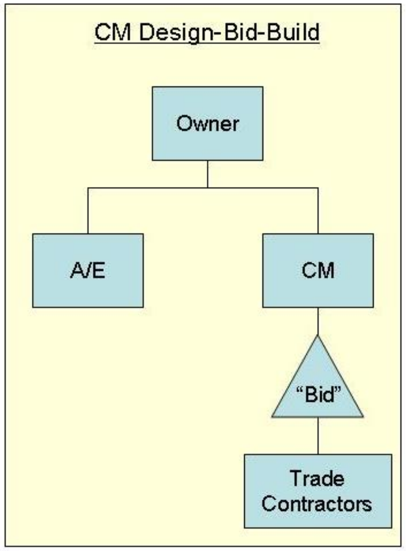
There are four primary project delivery methods commonly used to design and construct parking structures. Two Design Professional's Handbooks titled the *Design-Build Project Delivery* and the *Design/Contract-Build Project Delivery,* published by the American Council of Engineering Companies (ACEC), are helpful references.

Each method is described on the following pages, along with a graphical depiction of the contractual relationships for each:

1. Design-Bid-Build (D-B-B) projects are those where the owner selects and contracts with the lead designer (Parking Consultant or Architect/Engineer). They in turn represent the owner in defining the project and preparing drawings and specifications to meet the owner's needs for competitive bidding to contractors. Often on public projects the owner is required to select the lowest "responsive and responsible" bid, with the contractors' qualifications often not given consideration. The D-B-B method is sometimes referred to as the "traditional" process and is still the most common method.

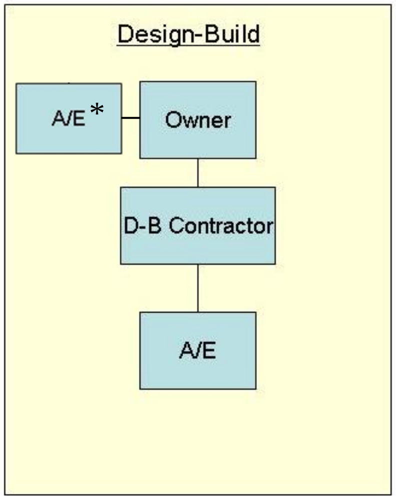
2. Construction Manager - Design-Bid-Build (CM D-B-B) is where the owner selects and contracts with the A/E who represents the owner in defining the project and preparing drawings and specifications to meet the owner's needs for bidding. However, the owner also retains a construction manager (CM) who works with the A/E during the design phases, sets the project schedule, and performs construction cost estimates. The CM bids the work to subcontractors for the various trades. This is a better method than D-B-B for projects where the owner wants fast track or phased construction.



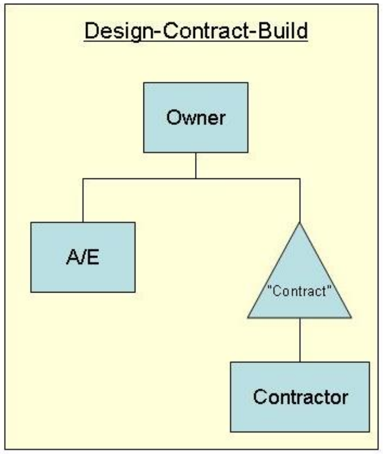


3. *Design-Build* (D-B) are cases where the owner retains a D-B contractor who in turn retains the A/E so there is a single entity responsible for both design and construction. Often the owner prepares or retains another A/E to prepare design build criteria documents as described below. Often, the owner can select the D-B team based on qualifications and cost, consistent with the bidding documents. There has been more interest in D-B type projects recently because of owners who perceive benefits regarding cost, schedule, and risk management.

4. *Design-Contract-Build* (D-C-B) are projects where the owner selects and contracts with the A/E. The A/E prepares preliminary documents that are the basis for the owner contracting with the contractor early in the design process, rather than waiting for final design documents to be prepared as for D-B-B. This method combines the advantages of the D-B-B and D-B methods while reducing many disadvantages to allow the owner to have the most qualified A/E and contractor involved in their project from the design phase through the completion of construction.



Optional but recommended; A/E prepares design build criteria documents that are basis for contract with contractor.



PARKING STRUCTURE DESIGN GUIDELINES

In recent years there has been an increasing interest and use of Design-Build in the construction of parking structures. Legislation has been enacted in many states to allow D-B to be used by public entities because prior laws required publicly funded construction contracts to be awarded based upon completed design documents.

Advantages of Design Build:

- Owner has a single point of responsibility for design and construction.
- Potential for better design and construction coordination because the A/E is working for the contractor.
- Owner does not have to arbitrate disputes between the A/E and contractor.
- Owner reduces their risk because the D/B contractor is responsible for errors or omissions in the design documents.
- Could be less administrative burden on the owner.
- Potential for accelerated schedule because the contractor is onboard at the beginning and because of the overlapping of design and construction work.
- Potential for lower costs due to the contractor being in greater control of the project and due to the accelerated schedule.
- Costs are well defined earlier in the process

Disadvantages of Design Build:

- The D-B contractor has the incentive to complete projects faster and less expensively which can mean reduced quality of materials and workmanship.
- The owner has less involvement and control of the design because the A/E represents the D-B contractor's best interests, not the owner's. Not only is this a disadvantage for the owner, but it creates a difficult conflict of interest for the A/E.
- The owner does not benefit from independent advice and input from the A/E and contractor.
- Greater definition of the project is required up front to define goals, objectives, and minimum requirements for project function, appearance, quality, materials, operation, etc. prior to bidding to D-B teams.
- More risk for D-B teams, which can negate the potential cost saving opportunities.

When owners decide that D-B is right for their project, they can have a better chance of achieving a successful project utilizing the following procedures.

Recommendations Regarding the Design-Build Delivery Method:

1. The owner should retain an A/E at project initiation to prepare the D-B criteria documents. This allows the owner to have more input into the concept design and set standards and criteria for the project. Also, due to the uniqueness of parking structures, it is important to have the A/E led by a parking consultant or for a parking consultant to have a significant role on the design team.

2. D-B criteria documents should clearly define the project scope, function, appearance, quality, materials, and operations. The level of completeness of these documents varies, but generally they are in the 10 to 30 percent range (between Schematic Design and Design Development level of completeness).

3. The owner should use a very transparent selection process to hire the D-B contractor, using the D-B criteria documents as the basis of the Request for Qualifications/Proposals (RFQ/RFP).

4. The selection process should consider the D-B teams' technical qualifications and experience in addition to cost. Typically, there is a weighting of selection criteria such as the experience and expertise of the firms and key personnel making up the team, experience of the team working together, technical merits of design, project appearance, quality and safety programs of the contractor, references, schedule, and cost. The selection criteria and weighting should be defined in the RFQ/RFP.

Parking structure built for Baylor University using the Design-Build delivery method

5. The owner's A/E who prepared the D-B criteria documents should continue on during the final design and construction to represent the owner's interest and help assure that the design and construction are completed in conformance with the D-B criteria documents.

As an alternative to using the D-B method, the Construction Manager at Risk (CMR) method can often result in a project that meets the owner's best interests because:

- The A/E contracts to the owner, thus representing their interests, not the contractors, which should enhance quality
- Design decisions can more easily be made that are in the best long-term interest of the owner, considering factors that will provide the lowest life cycle maintenance or operational cost, rather than emphasizing those that just provide the lowest first cost or schedule advantage
- The CM or contractor is onboard early in the design process so the A/E and contractor collaborate during design, enhancing innovation and opportunities to consider the contractor's cost saving ideas
- Similar schedule and cost advantages compared to D-B.
- Less risk for all parties as responsibilities can be allocated where they most belong

Successful parking structure projects have been completed using all four of the construction methods discussed above. Understanding the advantages and disadvantages of each and following a process to address them will help assure that the completed project is a success for the user, owner, community, designer and builder.

Sustainable Design – LEED Accreditation

While it is possible for parking structures to achieve certification, typically only occupied buildings receive certification for their sustainable design through the U.S. Green Building Councils (USGBC) Leadership in Energy and Environmental Design (LEED) accreditation program. However, parking structures that are part of a mixed-use project can help attain LEED points for the entire building project. A parking structure can be Parksmart certified by the USGBC, which considers a wide-range of design features and programs. Examples of sustainable design features for parking structures include:

- Sustainable Site Development
    - Green roofs
    - Solar panel sunshades on the top levels
    - Alternative transportation accommodations
- Water Savings
    - Water-efficient landscaping
    - Irrigation using non-potable water
    - Innovative technologies for water retention/detention
- Energy Efficiency
    - Energy efficient light sources such as natural lighting, fluorescent, induction, and light emitting diodes (LED)
    - Photovoltaic solar panels
    - Computerized lighting controls and voltage reduction

With the growth of electric vehicles, it is suggested that electric vehicle (EV)charging stations are provided and that electrical service is sized to permit the future expansion of EV charging stations. Also, EV charging stations are considered towards Parksmart certification.

It is suggested that the CCDC refer to the Parksmart certification standard regarding parking garage sustainability features and consider Parksmart certification for all parking structures.
(https://parksmart.gbci.org/certification)

PARKING STRUCTURE DESIGN GUIDELINES

- Materials and Resources Selection
  - Reuse of existing facades or shell
  - Use of recycled materials such as silica fume, fly ash, and steel
  - Carbon fiber reinforcement
  - Thin brick façade panels
  - Recycled rubber
- Indoor Environmental Quality
  - Low VOC products (e.g., paint, sealers and coatings)
  - CO monitoring and venting
  - Maximum natural ventilation and lighting (e.g., interior light wells)
  - Sustainable cleaning products
- Innovation and Design Process
  - Multi-modal facilities
  - Automated parking facilities on smaller site footprints
  - Designs for 60 - 75 year life
  - Bicycle storage lockers and racks

Adaptive Reuse

With the growth in shared mobility options and emergence of autonomous vehicles (AV) there is the potential for a dramatic reduction in future parking needs. One strategy to prepare for this potential reduction in parking demand is by designing adaptive reuse parking structures that could be later converted to another land use (i.e. residential, office, retail, etc.). Designing a parking facility for adaptive reuse will come with an initial cost premium in the 18-25% range. Design features associated with adaptive reuse parking structures are listed below.

- Increase floor-to-floor heights with the ground floor at a 15-foot minimum height and 12-foot height for each typical upper level.
- Implement flat floor plates.
- Additional expansion joints will be required.
- Design the ramp to be demolished and consider implementing exterior express ramps.
- Include a 25 - 30-foot wide light-well between parking bays to provide space for construction of additional elevator and stair cores.
- Design floor framing for additional load carrying capacity by including provision for adding columns and beams.
- Locate perimeter stair and elevator cores on the exterior of the floor plate.
- Provide additional floor drains to reduce impact of floor cross slope.
- Building columns, walls, and foundations could be designed to accept vertical expansion and the addition of a podium level for a public plaza recreational space or a one- or two-story light-framed building structure.
- Design for either the removal of perimeter vehicle and pedestrian guard rails or detail connection points to accept future installation

of building façade elements, including doors and windows to fully enclose the perimeter of the structure.

- Provide additional capacity in the electrical service, sanitary sewer, and fire protection systems.

Additional structural and architectural consideration may need to be identified based on whether the parking structure is cast-in-place concrete, precast concrete, or steel framed construction.

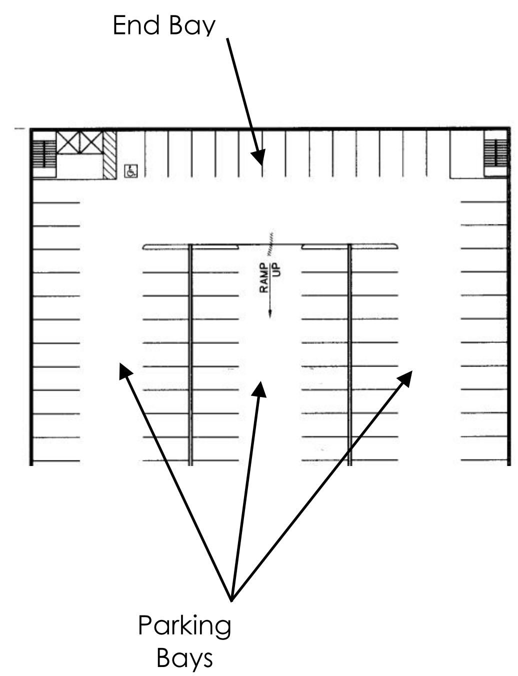
Another option to plan for a substantial reduction in parking demand is by designing the parking structure to be partially demolished. This would include installing expansion joints on each level for a portion of the parking structure and locating the ramp where it would not interfere with demolition or future circulation/access.

PARKING STRUCTURE DESIGN GUIDELINES

Site Requirements

Large and rectangular shaped sites are ideal for parking structures. Although flat sites are generally more economical to develop, sloped sites can provide design opportunities such as access on different levels and/or no ramping between levels. For a reasonably efficient parking layout, double-loaded parking "bays" range in width from about 54 to 60 feet, depending upon the angle of parking and the width of the parking space. The overall width of the structure should be determined based upon multiples of the chosen parking bay width. An ideal length for a parking structure is at least 240 feet. Longer sites provide the opportunity to park along the end bays, which provides more parking spaces, improves efficiency, and lowers the cost per space. A longer site also allows for shallower ramps which provide improved user comfort.

Generally, parking bays should be oriented parallel to the longer dimension of the site and preferably in the predominate direction of pedestrian travel. Walking distance tolerances from parking to a primary destination are typically 200 to 300 feet for shoppers, 500 to 800 feet for downtown employees, and 1,500 to 2,000 feet for special event patrons and students.



Site Constraints

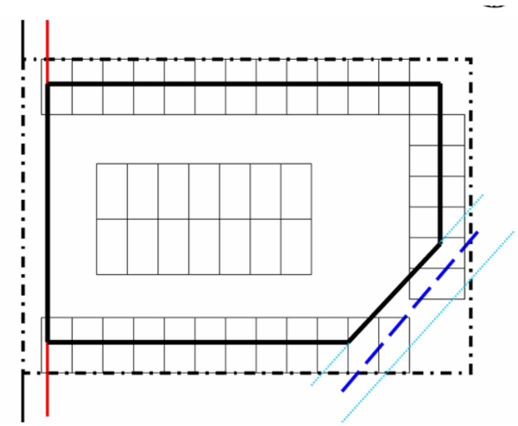
Other site issues to be considered when evaluating a potential site for a suitable parking facility include the following:

- Site Survey – a topographic survey of the site is a very important precursor to develop a conceptual plan. The site survey should delineate property lines, easements, and utility lines.

- Site Slope – The topographic information will define the slope of the site. Sometimes the slope of a site can used to reduce internal ramping in a parking structure, resulting in significantly lower costs. A parking structure that is built into a hillside can also reduce the visual mass of the facility.

- Geotechnical & Soils – Obtaining a soils report with sample borings and a geotechnical analysis early in the design process is prudent. If soils with poor bearing capacity are present on the site, the added cost for structural foundations can be significant.

- Codes and Ordinances – Municipal ordinances often specify setbacks, building height and bulk limitations, floor area ratio to site area, etc. than can significantly affect the allowable area on a site for a parking structure. The local planning organization may also impose development guidelines that must be followed.



Concept Design

Much of the remainder of these guidelines addresses issues and elements of parking structures that should be considerations during the conceptual design phase.

Parking Structures for People

An overall design principal to keep in mind is that parking structures are for people. Designing to accommodate the users of a particular structure will help produce a better parking structure.

- Different user types will have different needs.
- Some user types may need to be physically separated to ensure revenue control or for security reasons.
- Different users require different pedestrian circulation systems.
- Parking space widths and circulation geometry needs vary depending on the user type.
- Some vehicular circulation systems are better for specific user types:
    - Residential – Regular users enter and exit two times a day.
    - Education – May have peak loads in and out.
    - Hotel – Overnight guests, maybe event parking too.
    - Office – Low turnover. Regular users enter and exit two times a day.
    - Health Care Visitors –Wayfinding very important. Need to accommodate elderly drivers and passengers.
    - Health Care Staff – Shift time overlap and loading. Security issues, particularly at night.

- Retail – High turnover. Occasional users - wayfinding to and from vehicle.
- Elderly or Families with Small Children – Wayfinding again important. May need larger spaces and more elevators.
- Events – Easy quick loading and unloading of structure. Multiple vehicular paths. Consider revenue collection methods, typically a flat fee on entry. Provide queuing space. Consider pedestrian flow to event - avoid crossing traffic.
- Multiuse Garages – These guidelines focus on parking garage design for downtown Boise. Most of the garages in downtown will serve at least two user groups – short-term and long-term parkers – and may serve many other user groups. This is due to the fact that future garages will be located in activity centers that include office, entertainment, special event, restaurants, retail, lodging, and residential land uses – all of which have different parking characteristics. Attention should be given to creating entry, exit, and circulation designs that are flexible and adaptable to particular situations. Dual exit lanes that allow parkers with passes to exit quickly without having to wait in line with parkers who are paying should be considered to lower frustration levels for customers.

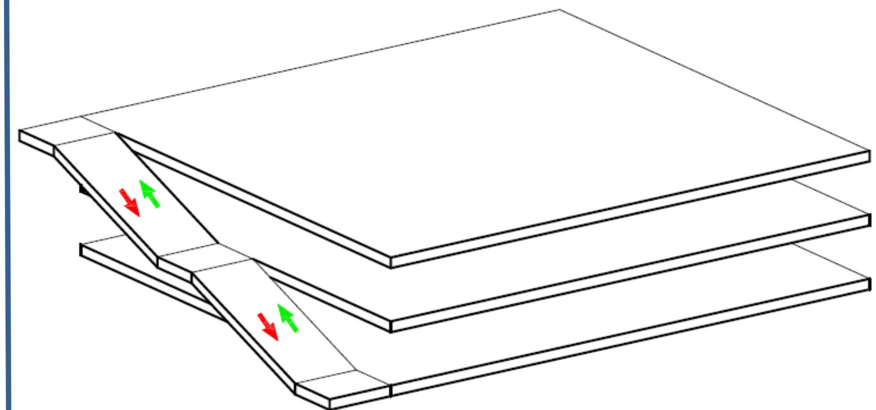
Circulation and Ramping

The basic circulation element for a parking structure is the continuous ramp with parking on both sides of the drive aisle. In continuous ramp structures, some of the parking floors are sloped in order for traffic to circulate from one level to another. Only on a sloping site that permits direct access to each level from the exterior roadways are ramps unnecessary; but they still may be desirable for internal circulation.

The basic criteria for choosing a circulation system are the simplicity or complexity of the system and the architectural compatibility. Ingress and egress capacities are also a consideration in the selection of a circulation system. Some circulation systems provide the opportunity for level façades which may be desirable.

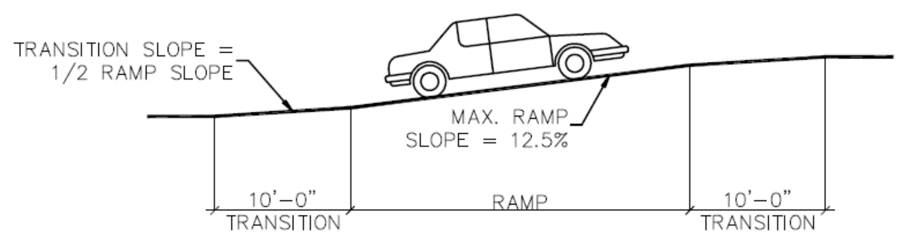
A parking ramp slope of 5% or less is preferred, although parking ramp slopes up to 7% are tolerated by the public in very dense urban areas. Parking ramp slopes should not exceed a 6.67% slope, which is the maximum parking slope permitted in the International Building Code (IBC). The acceptable ramp slope must also conform to the current Boise City Building Code.

Non-parking ramps are often employed at airports, casinos, large retail structures, for special event structures, and on small and irregularly shaped sites. Non-parking ramps consist of circular helixes (most common), express ramps (external), and speed ramps (internal). Non-parking ramp slopes should have a maximum slope in the 12% to 14% range. Non-parking ramp slopes up to 20% are sometimes considered if covered or equipped with snow melt systems. Non-parking ramp slopes are typically applied for flat parking levels and split-level garages.



Parking structures with non-parking ramps tend to be less efficient in terms of square feet of structure per parking space which directly increases the construction cost per parking space.

A grade difference of 8% or more requires transition slopes so vehicles do not bottom out. Recommended are minimum 10'-0" transition slopes at the top and bottom of the ramp that are one-half of the differential slope. For instance, two 10'-0" transition ramps sloped at 6.25% would be required at the bottom and the top of a ramp sloped at 12.5%.



Vertical Clearance

Provide 8'-2" minimum structural vertical clearance at all locations in the parking facility to support accessible vans. However, if ADA van parking is to be located at another parking facility, a 7'-4" clearance is acceptable. Care shall be taken to ensure that accessible routes are provided to allow movement between the parking structure and the egress exit. However, if there is a desire for truck or bus access on the ground floor to a loading dock or transit stop, a 13'-6" minimum clearance should be provided. Overhead height clearance bars should be placed at the entrance points and at the ramps if the ground floor clearance height is different than other levels. Ceiling height should try and remain consistent on each level, but if irregular changes in ceiling height are unavoidable from air ducts or pipe lines these features should be located along the wall edge of the facility over parking spaces and not drive aisles. Proper overhead clearance signage and yellow warning paint on these design features should be implemented to effectively notify patrons.

PARKING STRUCTURE DESIGN GUIDELINES

One-Way vs. Two-Way Traffic

One of the primary factors in the design of parking structure is determining the traffic flow: one-way or two-way. Typically, a parking bay for a one-way traffic flow is narrower than for a two-way flow. The available site dimensions will influence the parking bay width and thus also influence the circulation pattern. There are advantages and disadvantages to both circulation patterns. One-way traffic flow should never be combined with 90° parking. In parking facilities with one-way traffic flow, the angle of the parking stalls establishes the direction of vehicle traffic.

Advantages of One-Way Traffic Flow:

- Easier for parkers to enter/exit parking spaces.
- Vehicles are more likely to be centered in angled spaces.
- Less circulation conflict and reduced potential for accidents.
- Better visibility when backing out of a stall.
- Separation of inbound and outbound traffic and improved flow capacity of the circulation system.
- The intended traffic flow is self-enforcing.
- One-way traffic allows the angle of parking to be changed to accommodate changes in vehicle sizes.

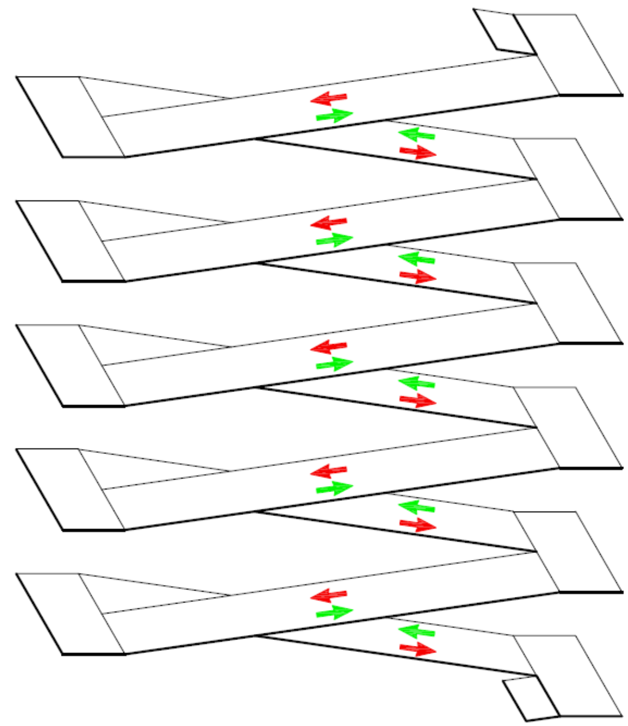
Advantages of Two-Way Traffic Flow:

- Wider drive aisles allow parkers to pass other vehicles.
- Wider drive aisles are safer for pedestrians.
- Better angle of visibility when searching for a parking space.
- Traffic flow follows its own pattern rather than one that is forced.
- Two-way traffic and 90° parking makes more efficient use of parking aisles (more spaces in a run).
- Two-way parking facilities can essentially operate as one-way facilities when there is heavy directional traffic.

Single Threaded Design

In order to develop a reasonably efficient free-standing parking structure, the **minimum** dimensions needed are about 122 feet in width by 155 feet in length. A width of 122 feet allows for a two-bay facility with two-way traffic flow and 90-degree parking. A facility with two-way traffic and a five-foot rise along each bay requires approximately 155 feet in length for a minimum floor-to-floor height of about ten feet. That is, one 360-degree turn within the facility equates to a vertical rise of ten feet. A structure in this configuration has sloping floors along both façade sides. However, sloping floors can make façade treatments challenging. On larger sites that allow a structure length of about 255 feet, one bay can be sloped rising 10 feet with opposite façade having a "level" floor.

Because of the number of 360° turns needed to ascend in a single threaded structure, the number of levels (floors) should preferably be limited to a maximum of six, otherwise the number of turns required, and the number of spaces passed becomes inconvenient. A structure with a two-bay single thread design has a capacity for a maximum of approximately 750 spaces. The isometric diagram to the right represents a two-bay single-threaded helix.



Single Threaded Helix with Sloping Floors

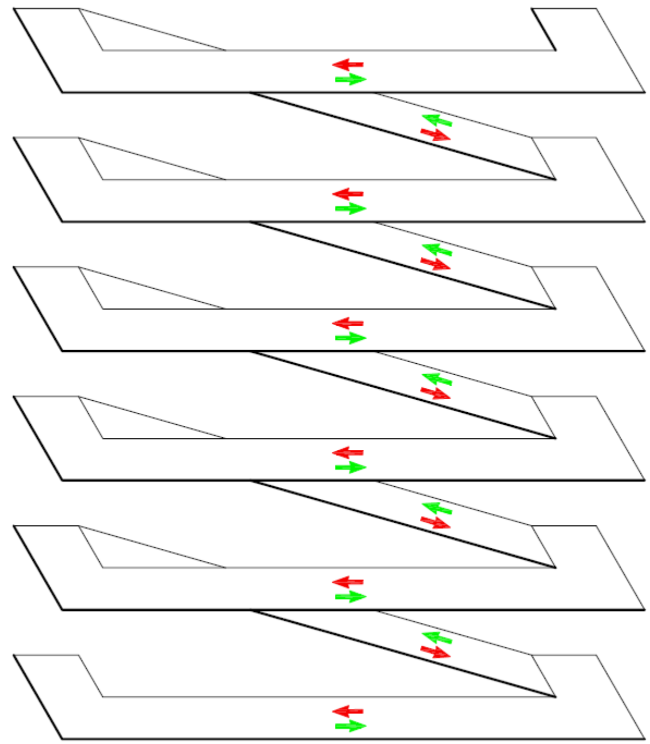
PARKING STRUCTURE DESIGN GUIDELINES

Principal Advantages of a Single-Threaded Helix:

- Repetitive and easy to understand for users.
- Potentially more flat-floor parking and level façade elements.
- Better visibility across the structure, which enhances security.

Principal Disadvantages of a Single-Threaded Helix:

- More revolutions required going from bottom to top and top to bottom.
- Two-way traffic bays have less flow capacity than one-way traffic bays. Traffic in both directions is impeded by vehicles parking and vacating a space.



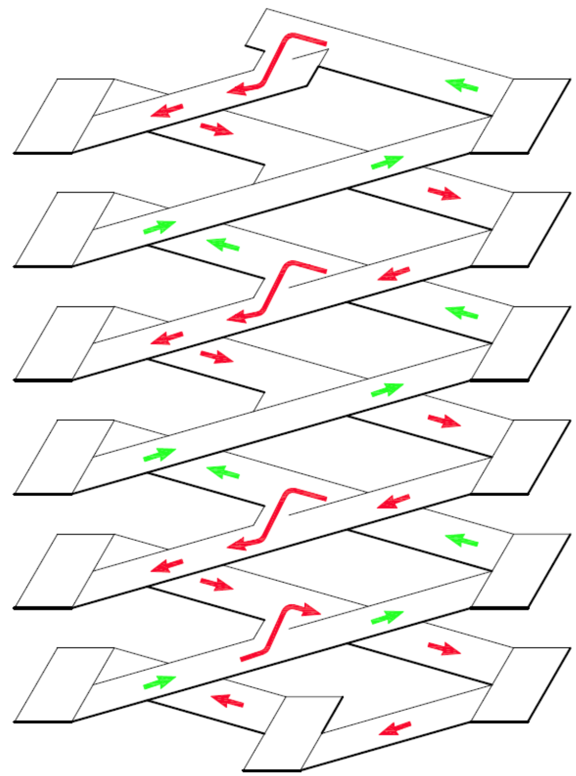
Single Threaded Helix with One Level Bay

PARKING STRUCTURE DESIGN GUIDELINES

Double Threaded Design

A facility with a one-way circulation system and angled parking can be provided in a double-threaded helix with modules ranging from 54 to 58 feet in width, depending upon the angle of parking. The preferred angles of parking for an efficient layout are 60°, 70° and 75°. A double thread, which requires a ten-foot rise along each module, requires 240 feet in length. More efficient layouts can be achieved on longer sites. The isometric right represents a two-bay double-threaded helix with one-way traffic.

A double-threaded helix can work with either one-way or two-way traffic flow, although one-way traffic is more common. A two-way double threaded design can be configured as two separate structures with no vehicular connection. A double-threaded helix rises two levels with every 360 degrees of revolution, which allows for two intertwined "threads" and the opportunity to circulate to an available parking space without passing all parking spaces as inbound and outbound traffic can be separated. Because of this, double-threaded helices are often recommended for larger facilities with seven or more levels. A two-bay double thread has a functional system capacity for up to approximately 2,000 spaces with angled parking and one-way traffic flow.



One-Way Double-Threaded Design

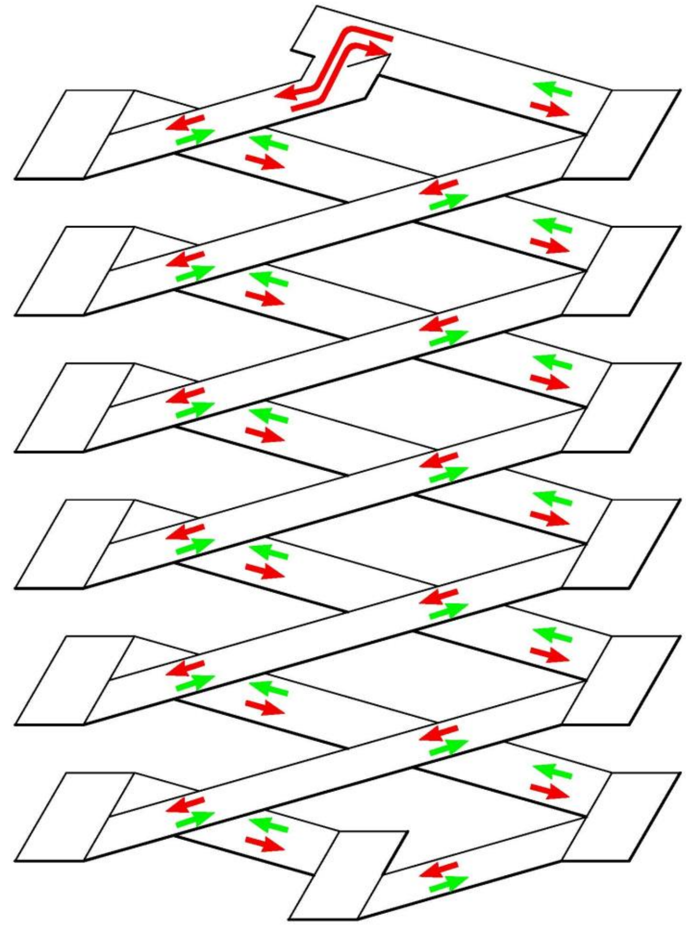
PARKING STRUCTURE DESIGN GUIDELINES

Principal Advantages of a Double-Threaded Helix:

- Efficient circulation and more traffic flow capacity
- Pass fewer spaces both inbound and outbound.

Principal Disadvantages of a Double-Threaded Helix:

- Can be complex and confusing, particularly in finding one's vehicle upon return to the parking facility.
- Two-sloped bays and minimal flat-floor parking.

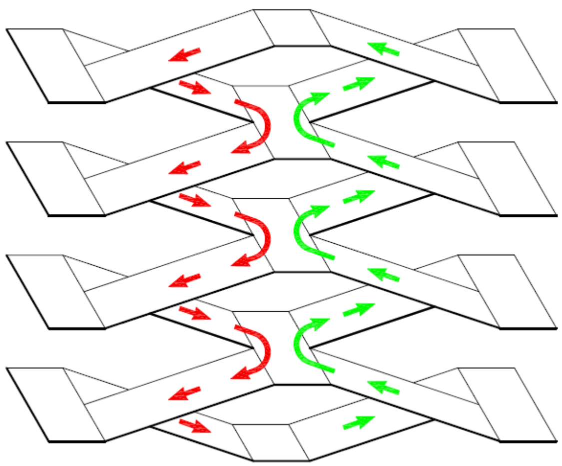


Two-Way Double-Threaded Design

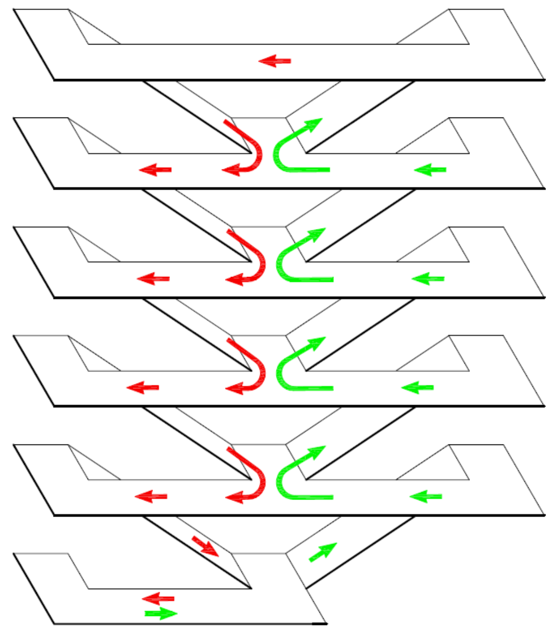
PARKING STRUCTURE DESIGN GUIDELINES

Other Circulation Systems

There are other parking and circulation systems that are often used in parking structures.

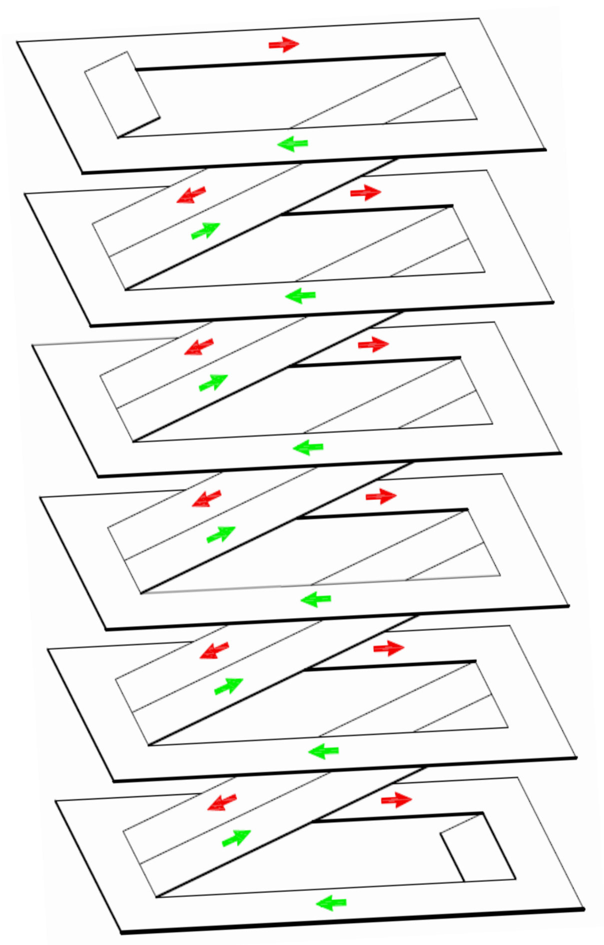


End-to-End Helix Both Bays Sloped

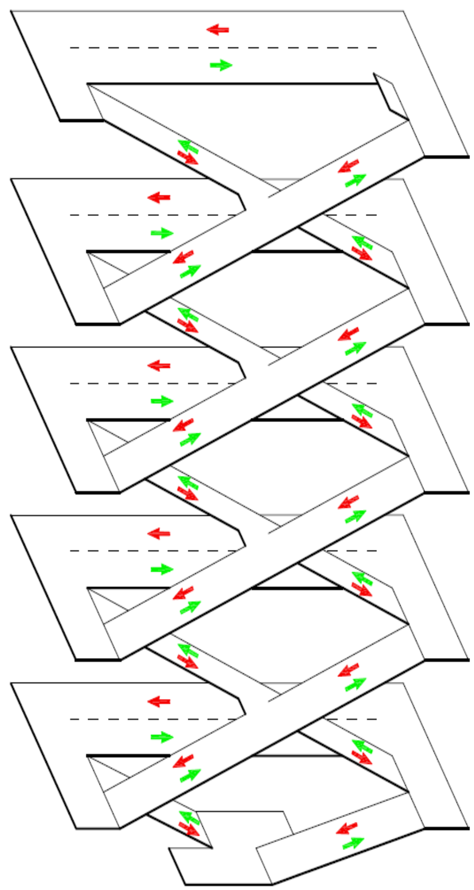


End-to-End Helix One Bay Sloped

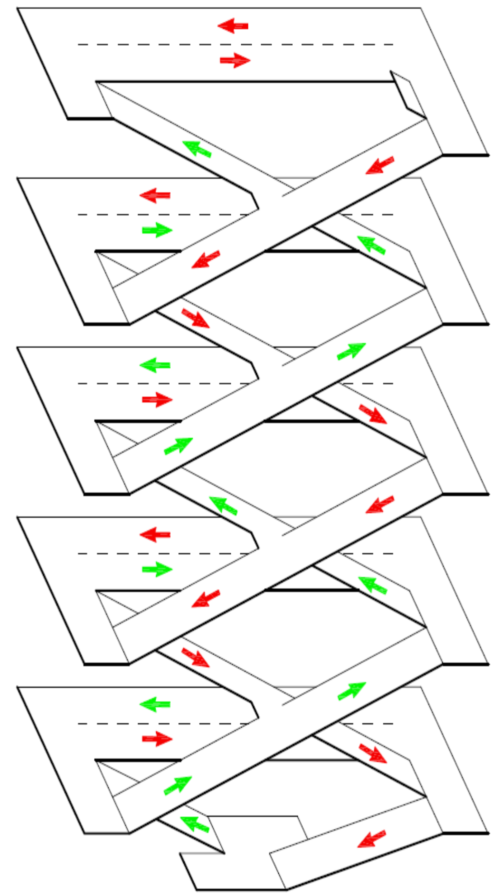
PARKING STRUCTURE DESIGN GUIDELINES



Side-by-Side Helix



Two-way Double-Threaded w/ Flat Bays



One-way Double Threaded w/ Flat Bays

Access Design

Vehicle entrances should be visible and easily identifiable. The minimum distance of entry/exits from corner intersections is at least 75 to 100 feet (preferably 150 feet). Entrances and exits should have clear lines of sight. It is preferable to enter a facility from a one-way street or by turning right from a two-way street and to exit a facility by turning right on a low-volume street. High traffic volumes and left turns can slow exiting and cause internal traffic backups. Consideration should be given to acceleration/deceleration lanes on busy streets. Gates should be located far enough away from the street to allow at least one vehicle behind the vehicle in the service position (at a ticket dispenser, card reader or cashier booth) without blocking the sidewalk. Entry/exit areas that have parking control equipment should have a maximum 3% slope.

It is very important to provide the appropriate number of entry/exit lanes to meet projected peak traffic volumes. The number of lanes is a function of user groups served, peak-hour traffic volumes, and service rates of the parking control equipment. It is recommended to have a parking professional prepare a lane and queuing analysis to guarantee sufficient entry and exit capacities.

Cross-traffic at entry/exits should be minimized and preferably eliminated. When placing vehicle entries and exits together on one-way streets it is preferable to avoid "English" traffic conditions where traffic keeps to the left instead of to the right. Pedestrian/vehicular conflicts should be minimized by providing a pedestrian walkway adjacent to entry/exit lanes. Stair/elevator towers should be located so pedestrians do not have to cross drive aisles on their way to primary destinations.

Important Issues for Vehicle Entry and Exit Lanes:

- The approach and the departure area from the lanes will also affect the rate of flow into or out of the structure. Tight turns equal a slower throughput.
- Pedestrian safety at entry and exit portals is paramount. Consider the vision cone of drivers entering or exiting the facility.
- Check and recheck vehicle turning radii at all entry / exit lanes and adjacent ramps.
- Vehicle queuing analyses should be performed to ensure traffic does not back-up onto the exiting street system or the inside of the facility during peak periods of traffic flow.

PARKING STRUCTURE DESIGN GUIDELINES

Parking Geometrics

Parking geometrics refers to parking stall and drive aisle dimensions. Parking dimensions have been developed to comfortably accommodate the composite design vehicle, which refers to the dimensions of the 85th percentile vehicle in the range of vehicles from smallest (zero percentile) to largest (100th percentile). The composite design vehicle is the size of a Ford F150 truck (6'-7" x 17'-3").

The table on this page lists City of Boise parking geometrics by parking angle for standard and compact spaces. The City's Zoning Code should be adhered to regarding parking space dimensions.

Parking Angle A	Stall Width B	Curb Length Per Car C	Stall Depth D	Driveway Width E
0°	9'- 0"	23'- 0"	9'- 0"	12'- 0"
20°	9'- 0"	26'- 4"	15'- 3"	11'- 0"
30°	9'- 0"	18'- 0"	17'- 8"	11'- 0"
40°	9'- 0"	14'- 0"	19'- 6"	12'- 0"
45°	9'- 0"	12'- 9"	20'- 5"	13'- 0"
50°	9'- 0"	11'- 9"	21'- 0"	14'- 0"
60°	9'- 0"	10'- 5"	21'- 10"	16'- 0"
70°	9'- 0"	9'- 8"	21'- 10"	18'- 0"
80°	9'- 0"	9'- 2"	21'- 4"	20'- 0"
90°	9'- 0"	9'- 0"	20'- 0"	22'- 0"

MINIMUM STANDARDS FOR COMPACT VEHICLES

Parking Angle A	Stall Width B	Curb Length Per Car C	Stall Depth D	Driveway Width E
45°	7'- 6"	10'- 6"	16'- 0"	11'- 0"
60°	7'- 6"	8'- 9"	16'- 9"	14'- 0"
75°	7'- 6"	7'- 10"	16'- 4"	17'- 5"
90°	7'- 6"	7'- 6"	15'- 0"	20'- 0"

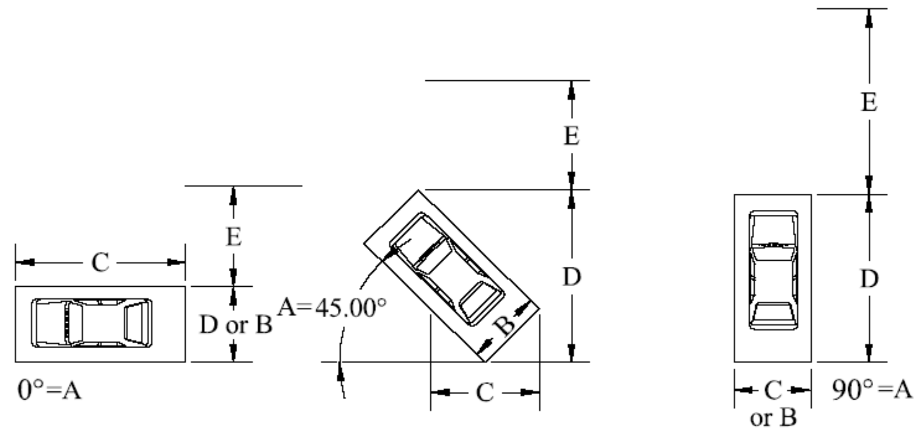
PARKING STRUCTURE DESIGN GUIDELINES

The City's parking dimensions for standard spaces exceed industry standards. The table on the following page lists parking geometrics by User Comfort Factor (UCF) which correlates with a Level of Service (LOS) approach. Traffic engineers developed the LOS approach to classify traffic conditions on roadways from A (free flow) to F (gridlock). The UCF/LOS approach has been adopted by many parking consultants to help classify conditions in parking facilities. The recommended UCF categories for parking geometrics are as follows:

UCF 4 = LOS A = Excellent
UCF 3 = LOS B = Good
UCF 2 = LOS C = Acceptable

LOS criteria should be related to the needs and concerns of users. Generally, users with low familiarity and high turnover should be accorded a higher UCF. If the city's parking standards are not used, we recommend minimum UCF 3 geometrics for moderate to high turnover parking (visitor, retail, etc.) and minimum UCF 2 geometrics for low turnover parking (employee, commuter, resident, etc.).

We recommend using "one-size-fits-all" parking spaces rather than segregating standard and small car spaces. However, if they are used, small car spaces should not exceed 15% to 20% of the total capacity of a facility.



PARKING STRUCTURE DESIGN GUIDELINES

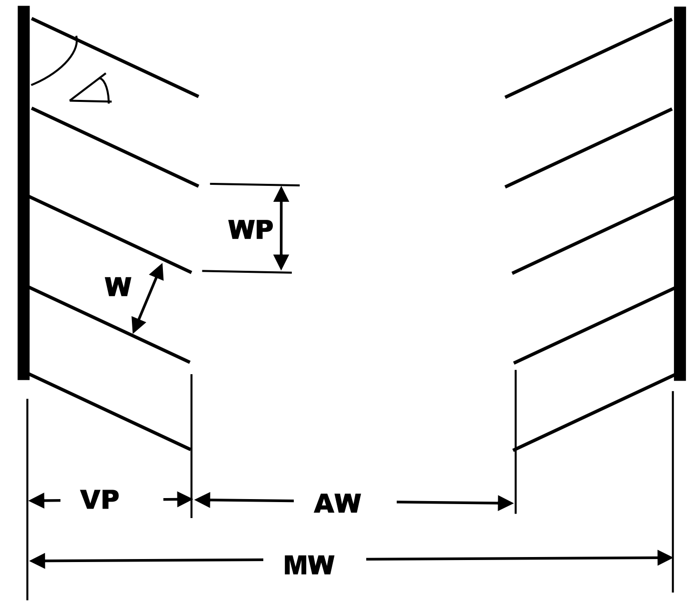
Parking Layout Dimensions

PARKING LAYOUT DIMENSIONS

Parking Angle	Stall Width Projection (WP)	Module Width (1) (MW)	Vehicle Projection (VP)	Aisle Width (AW)
User Comfort Factor 4				
		w = 9'-0"		
45	12'-9"	49'-10"	17'-7"	14'-8"
50	11'-9"	51'-7"	18'-2"	15'-3"
55	11'-0"	53'-0"	18'-8"	15'-8"
60	10'-5"	54'-6"	19'-0"	16'-6"
65	9'-11"	55'-9"	19'-2"	17'-5"
70	9'-7"	57'-0"	19'-3"	18'-6"
75	9'-4"	58'-0"	19'-1"	19'-10"
90	9'-0"	62'-0"	18'-0"	26'-0"
User Comfort Factor 3				
		w = 8'-9"		
45	12'-4"	48'-10"	17'-7"	13'-8"
50	11'-5"	50'-7"	18'-2"	14'-3"
55	10'-8"	52'-0"	18'-8"	14'-8"
60	10'-1"	53'-6"	19'-0"	15'-6"
65	9'-8"	54'-9"	19'-2"	16'-5"
70	9'-4"	56'-0"	19'-3"	17'-6"
75	9'-1"	57'-0"	19'-1"	18'-10"
90	8'-9"	61'-0"	18'-0"	25'-0"

Note: (1) Wall to wall, double loaded aisle.

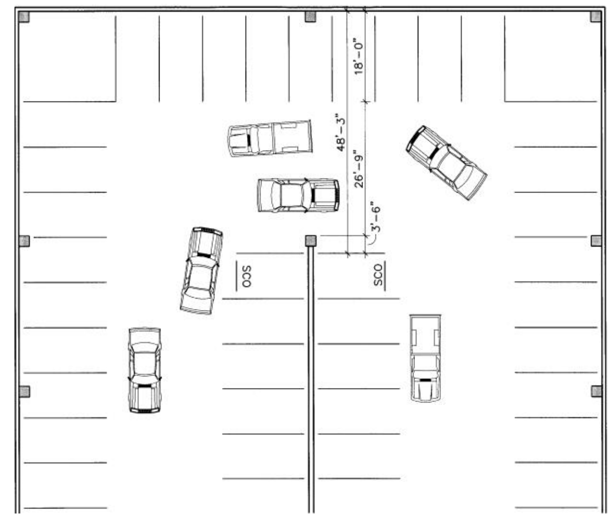
Parking Angle	Stall Width Projection (WP)	Module Width (1) (MW)	Vehicle Projection (VP)	Aisle Width (AW)
User Comfort Factor 2				
		w = 8'-6"		
45	12'-0"	47'-10"	17'-7"	12'-8"
50	11'-1"	49'-7"	18'-2"	13'-3"
55	10'-5"	51'-0"	18'-8"	13'-8"
60	9'-10"	52'-6"	19'-0"	14'-6"
65	9'-5"	53'-9"	19'-2"	15'-5"
70	9'-1"	55'-0"	19'-3"	16'-6"
75	8'-10"	56'-0"	19'-1"	17'-10"
90	8'-6"	60'-0"	18'-0"	24'-0"



PARKING STRUCTURE DESIGN GUIDELINES

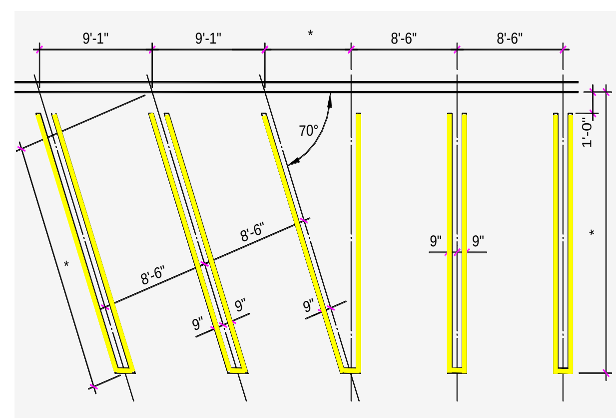
Parking spaces adjacent to walls, columns, elevators, stairs, etc. should be widened, if possible, by one foot so that vehicle doors can be more easily opened.

At the ends of the parking rows, sufficient space must be provided to allow drivers to negotiate the turn. Typically, a striped buffer no smaller than 3'-0" shall be provided between the last parking stall and the drive aisle. A minimum recommended inside vehicular turning radius is 15 feet with a minimum outside turning vehicular radius of 30 feet. Larger dimensions should be used in higher speed conditions. If single-unit trucks or busses are allowed access in the facility a minimum inside vehicular radius of 28 feet and minimum outside turning vehicular radius of 42 feet is suggested.



End bay drive aisles with two-way traffic should be a minimum of 26' wide for improved turning maneuverability. Wider end bay drive aisles are recommended for high turnover parking facilities. If possible, it is also suggested for more comfortable turns to hold back the first stall on either side of the turning bay. Small-Car-Only (SCO) spaces are also recommended at the ends of interior parking rows. It is very difficult to make a turnaround only one row of parking. Refer to the following graphic.

Double stripes for space striping are recommended as they help parkers center their vehicles between stripes, maximizing the space between vehicles (refer to the graphic below). Also recommended is the use of traffic yellow paint for stall striping as yellow paint is more visible over time than white paint.



Kimley»Horn

PARKING STRUCTURE DESIGN GUIDELINES

Parking Layout Efficiency

Parking Efficiency is expressed in square feet of construction per parking space. Parking efficiency directly correlates with the construction cost per space. Build less structure per space and the cost per space drops. Non-parking speed ramps for example increase the square feet per space.

Parking efficiency should be calculated considering the total parking structure size including the stairs and elevators and non-parking ramps. Any retail space that is incorporated within the structure is also usually included in the calculation.

Typical ranges of parking structure efficiencies are:

- Short Span Structural System = 330 to 390 Square Feet per Space
- Long Span Structural System = 300 to 340 Square Feet per Space
- Mixed Use Developments with retail, residential and parking can be as high as 400+ square feet per space

PARKING EFFICIENCY MAKES A BIG DIFFERENCE – EXAMPLE

- 360 sf / space X 500 spaces X $45 / sf = $8,100,000
- 330 sf / space X 500 spaces X $45 / sf = $7,425,000

A difference of $675,000 or $1,350 per space!

Pedestrian Requirements

Pedestrian traffic is equally as important in a parking structure as vehicle traffic. A safe, secure and well signed pedestrian path must be provided. Pedestrian access at the grade level should be separated from vehicular ingress and egress. Pedestrian access is usually adjacent to stair/elevator towers. It is also desirable to place a dedicated pedestrian aisle adjacent to a vehicle entry/exit because pedestrians are naturally attracted to these openings. Maximum lines of sight for both pedestrians and vehicles should be provided, and mirrors and warning devices should be incorporated when necessary. Access locations should be restricted to a few locations for security reasons.

A minimum of two stairs are required to meet code-required means of egress for fire exits in parking structures. Stairs <u>shall</u> be open or glass enclosed and be <u>visible to the street</u> for security reasons. The minimum stair width in parking structures is 44" and wider stairs are required for special events. Travel distance between exit stairs is specified in the IBC and is a maximum 300 feet without a sprinkler system and 400 feet with a sprinkler system. Stairs are usually placed in dead corners.

Elevators should be located at terminus in the direction of pedestrian travel. Hydraulic elevators can be used for up to 5 levels or 50' to 60'. Traction elevators should be used beyond 5 levels. The minimum capacity and size is 3,500 lbs. and 5'-0" x 7'-0". The number of elevators is based on the number of spaces, the number of levels, user group(s) served, peak-hour flow rates, and the size and capacity of the elevator. A parking consultant can provide a preliminary indication of the number of elevators based on a formula that takes into account the information presented above. We highly recommend that elevators have glass backs for security reasons. Enclosed lobbies are recommended for protection from the elements on the top level.

Accessible Parking Requirements

The following table presents the required number of accessible parking spaces based on the total number of spaces provided in any given facility.

The accessible parking requirement for an institution like a hospital campus is not based on the total parking capacity but rather on the capacities of the individual facilities within a parking system, which always results in the provision of more accessible spaces overall. Accessible spaces for the institution do not have to be provided in each parking area but can be supplied at a different location provided at least equivalent accessibility in terms of distance, cost, and convenience is provided.

All accessible spaces are 8' wide with either a 5' or 8' access aisle. An accessible space and access aisle cannot be placed at a location with a running or cross slope greater than 1:50 (2%).

The current 1 to 8 ratio for the provision of van accessible spaces is changing to 1 to 6, and it is required to round up to the nearest whole number when determining the number of van spaces. The barrier free section of the International Building Code (IBC) has the same requirement. It is recommended to use the new 1 to 6 ratio when determining the number of van spaces. Van accessible spaces require minimum 8'-2" vertical clearance and have 8'-0" wide access aisles.

Each accessible space must have a sign showing the international symbol of accessibility mounted at least five feet above the pavement. All van accessible spaces must have an additional "Van Accessible" sign mounted below the symbol of accessibility (mount minimum of 5' above pavement with other sign above).

Required Accessible Spaces

Total Spaces in Facility	Minimum Accessible Spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,000	2% of total
1,001 and over	20 plus 1 for each 100 over 1,000

ADA requires rounding up to the next whole number when calculating the required number of spaces based on a percentage or ratio. For example, a parking facility with 810 spaces will have 17 accessible spaces (810 x .02 = 16.2 = 17 spaces), and 3 spaces will have to be van accessible (17 ÷ 6 = 2.833 = 3).

Accessible stalls cannot share access aisles when the parking is angled. Access aisles for van spaces must be on the passenger side when the parking is angled because vehicles cannot back into these spaces.

All accessible spaces must have an accessible route to public streets or sidewalks, accessible elevators, or accessible building entrances. An accessible route must have a minimum unobstructed width of 3'. A vehicle way (drive aisle) may be part of an accessible route, although it is preferred to place the accessible route at the front of the stalls. An accessible route can only pass behind other accessible spaces. It is permitted to cross a vehicle way with an accessible route. Automatic or push-button door opening devices will be needed if the accessible path includes doors that patrons will need to enter/exit.

The running slope along an accessible route cannot exceed 1:20 (5%) and the cross slope cannot exceed 1:50 (2%).

It is recommended to cross hatch all access aisles and accessible routes.

Ultimately, accessible parking must be provided as required by existing City building and zoning codes. However, it is recommended that the standard ADA requirements detailed in this section be used if they exceed existing City requirements.

All parking access and revenue control equipment should be designed to meet ADA standards. Parking facilities should try to integrate equipment that allows for convenient access, such as: Bluetooth payment/access, license plate recognition (LPR) access, and gateless systems with pay-by-plate/space stations.

Safety and Security

Because curbs can be a potential tripping hazard, curbs in all pedestrian areas (at the end of parking rows, around stairs and elevators, dead corners, etc.) are strongly discouraged. The faces and edge of curbs that remain should be painted traffic yellow to enhance visibility.

Glass-backed elevators and glass enclosed and/or open stairways, visible to the adjacent street, are highly recommended for enhanced security. Security fencing should be installed below stairwells to eliminate the possibility of a person hiding under the stairs.

Lighting that enables users to see and be seen is one of the most important security features of a parking structure. A separate discussion on lighting is included in these guidelines.

Other important aspects of security design:

- Short span construction is not recommended. In short span construction, the columns are placed more closely together; thereby adding additional obstructions to lines of sight
- Security fencing at the ground level should not be climbable
- Security fencing ensures pedestrians enter/exit the facility only at designated pedestrian points
- Landscaping should not provide hiding places
- Roaming security guards
- Monitors in security office
- Security cameras are a deterrent to criminal activity.
- Tape or cloud-based back-up should be incorporated with security cameras
- Intercom systems should offer two-way communication

- Monitoring and two-way communication systems should work seamlessly together to prevent operational issues
- Panic alarms and two-way communication systems are recommended in prominent locations on each level

In general, assure that as much openness as possible is provided in the design to improve sight lines, eliminate hiding places, and enhance perceived security.

Lighting

The project's electrical engineer should perform an energy life cycle analysis of competing light fixture types, on a case by case basis, to ensure maximum value on investment. The goal is to implement lighting with a low Lighting Power Density (LPD), which is the ratio of the wattage (W) of the installed lighting compared to the floor area (square footage) of the illuminated space. The lighting should also have a long lifetime to limit the times it needs to be replaced.

Light sources that may be considered include high pressure sodium, metal halide, induction, T8 fluorescent, or LED fixtures. LED lighting fixtures are preferred as they offer some advantages, including: more energy efficient, cost efficient, and longer lamp and fixture life. However, an energy life cycle analysis should be conducted prior to selecting a lighting source. Note: CCDC has adopted LED lighting as their preferred lighting option as of this writing (2019).

Some of the benefits of proper lighting in a parking facility include:

- Key Security Measure
- Enhances User Comfort & Perception of Safety
- Business Attraction Amenity
- Permit Safe Movement for Pedestrians and Vehicles
- Enhances Signage Visibility
- Typically, light levels are not code regulated
    - Except emergency lighting @ 1 footcandle minimum
- Industry Standards
    - Illuminating Engineering Society of North America (IESNA) publishes minimum garage lighting standards
    - Liability risk for non-compliance

PARKING STRUCTURE DESIGN GUIDELINES

The recommended lighting standards listed in the table to the right, slightly exceed the Illuminating Engineering Society of North America (IES) lighting standards for parking facilities. Staining the ceilings white to enhance light levels is suggested.

Recommended Parking Structure Lighting Standards

Areas	Minimum Horizontal Illuminance on Floor Footcandles	Minimum Vertical Illuminance at 5 feet Footcandles	Maximum to Minimum Uniformity Ratio
General Parking & Pedestrian	2	1	10:1
Ramps and Corners			
Days	2	1	10:1
Nights	1	0.5	10:1
Entrance Areas			
Days	50	25	10:1
Nights	1	0.5	10:1
Stairways	7 avg.		10:1

Lighting Entry and Exit Lanes

- Provide Additional Lighting (50 fc) for 10'-60' Zone from Building Edge (Transitional lighting)
- Include Daylight Infiltration (> 15 fc)
- Typically, 10' X 10' Spacing of 150 W Fixtures
- Turn 2/3 of Fixtures Off @ Night

Light Source Types

- **High Pressure Sodium**
  - Golden White HPS Light Color
  - Common Parking Structure Lighting
  - Lamp Life = 24,000-28,500 Hours
- **Metal Halide**
  - White Light Color
  - Perceived Greater Brightness
  - Lamp Life = 15,000 Hours
  - Operating Cost Slightly **>** HPS
- **Light Emitting Diode (LED)**
  - Emerging Technology
  - Energy Efficient
  - Long Life
- **Fluorescent**
  - White Light Color
  - New Technology – Use in Cold Climates

- Cold Weather Ballast (If Temps < 50° F)
- Phosphor Coating
- Sealed Fixtures

- Lamp Life = 30,000 Hours
- Energy Cost Effective

- **Induction Lighting**
  - White Light – Best color rendition
  - Instant Ignition Long Life Bulbs = 100,000 Hours
  - Energy Efficient
  - High Initial Costs

Lighting Expense Reduction Strategies

We recommend that the exterior bay lighting of "open" parking structures as well as roof top lighting be on separate circuits so that these lights can be turned off during the day to reduce energy consumption/costs as depicted in the photo to the right.

PARKING STRUCTURE DESIGN GUIDELINES

Before and after photographs showing the results of new LED lighting (compared to old high-pressure sodium light fixtures)

Signage and Wayfinding

Parking facilities can be very large, complex, and confusing. A well-designed graphics and signage system will effectively communicate necessary information to patrons, reduce confusion, improve safety, and enhance the overall user experience.

The *PARK BOI Branding Guide* created in March 2016 should be applied when implementing parking signage, including for kiosks and digital signage displays. The *PARK BOI Branding Guide is included in these design guidelines as Appendix A for reference*. Sign messages should be simple and succinct. Messages on signs that are to be read quickly, such as vehicular signs, should be no more than 30 characters and six words in length. The typeface used should be simple and easy to read. Signs with lower case letters and initial caps are most easily read. The simple block arrow is recommended for parking signs. If a left turn is required, the arrow should be placed on the left side of the sign. The opposite is true for a right turn.

In parking structures, signs with a dark background and white letters are more easily read than signs with a white background and dark letters. The opposite is true in surface lots, where signs with white background and dark letters are better.

Vehicle Signs

Examples of vehicular signs include "Park" and "Exit" directional signs. Vehicular signs are ten or twelve inches in height with six or seven-inch letters. Ten-inch signs are recommended for precast structures where sign visibility can be a problem. Vehicular signs should be centered over the drive lane or centered over the drive aisle when signs are mounted back-to-back.

Pedestrian Signs

Examples of pedestrian signs include "Level #," "Remember Level #," "Row #,"and "Stair" and "Elevator" identification and directional signs. Pedestrian signs can be all one color or be color-coded by level. Pedestrian signs should be clearly distinguishable from vehicle signs so as not to interfere with vehicular traffic. Pedestrian signs in parking bays are most effective if located perpendicular to traffic flow, and they should be placed at the rear of parking stalls. Color-coding is often used to help patrons find their vehicles. It is not necessary to provide color-coding in parking facilities that are three levels or less. When color coding, it is recommended to use primary and secondary colors including red, blue, yellow, orange, purple, and green. If there are more than six levels that need to be color-coded, it is recommended to use white, brown, and black. Confusing colors such as turquoise (blue or green?) and taupe (brown, tan, or gray?) should be avoided.

The elevator core area provides an excellent location to utilize super graphics. Super graphics is defined as a graphic that covers a large area and is generally painted on a vertical surface, such as painted walls or elevator doors, with level designation incorporated.

Once colors have been determined, the color coding must appear on each parking floor (e.g., on columns and walls) and adjacent to elevator lobbies and stairwells – as well as inside elevators.

For garage exit lanes across high-activity sidewalks "Caution Car Coming" electronic signage and audible alarms should be employed to notify pedestrians of a vehicle exiting the parking structure.

Level Theming

"Level Identification Theming" and other wayfinding aids provides an opportunity to enhance parking interior environment enhancement while also providing a practical tool to assist patrons in remembering where they parked. Several creative examples or illustrated below.

Entry Signs

Emphasizing the entrance to a parking facility is important. Large illuminated signs are often used to emphasize the facility entry and attract patrons. These signs often spell out "Parking" or use the International symbol for parking. Architectural features, such as an arch, canopy, or some different treatment of the façade, are often used to highlight the entry area as well. A height clearance bar is required for all parking structures, including the top (surface) level of below-grade facilities to prohibit over-height vehicles. Generally, the height clearance bar is located at the facility entrance(s). There may be instances when the clear height in a parking structure changes from one level to another (for example, a higher ground level than typical level to accommodate ADA vans), which may require additional height clearance bars within the facility itself. Generally, the height clearance bar is an eight-inch PVC pipe.

Regulatory Signs

Regulatory signs are often used in parking facilities. Examples include "STOP," "YIELD," "ONE WAY," "NO PARKING" "DO NOT ENTER," and accessible parking signs. When used it is imperative that they comply with local and federal requirements. The Manual of Uniform Traffic Control Devices (MUTCD) provides examples of standard highway signs.

Illuminated Signs

Illuminated signs are becoming more and more common in parking facilities. Technology has advanced significantly in recent years and illuminated signs have become more reliable. Generally, illuminated signs are used for the following parking applications:

- Entry and Exit Lanes (Open in green/Closed in red)
- Facility Full Signs
- Stop (red)/Go (green)
- Level Space Capacity
- Directional Control
- Fee Display
- Space Count Systems
- Variable Message Signs

Pavement Markings

Pavement makings should conform to Manual of Uniform Traffic Control Devices (MUTCD) or local standards. MUTCD specifies that white paint be used for markings for traffic flow in the same direction and yellow paint used for traffic flow in opposite directions, which implies a warning.

Pavement markings can be an effective way to direct and control traffic flow in a parking facility. However, pavement markings must be re-applied due to wear and deterioration from vehicular traffic. Pavement arrows may enhance traffic flow. They are often utilized on surface lots or the top level of parking structures where overhead directional signage is not possible. Traffic arrows are also commonly used in facilities with a combination of one-way and two-way traffic flow.

Drainage

Proper floor drainage is essential for all types of parking structures in all climates. While direct rain or snow may not enter all areas of the parking garage, windblown rain and snow and/or vehicles carrying ice, snow and water will distribute water throughout the facility. Heavy rains will also overload top floor drains and water will run down the ramped floors to lower levels. In addition, the frequent floor wash-downs (e.g., washing the parking surfaces/floors) that should be part of a good maintenance program are a source of water throughout the parking facility. If the floor is not adequately sloped, water is allowed to pond and deterioration will accelerate beneath the ponds.

The top-level drain system should be designed to accept a 10-year design rainfall or as determined by local historical climatology. Drains should be strategically placed at the bottom of the top-level ramp. Drain lines should be insulated to prevent frozen pipes resulting in cracks.

A design slope of 2%, or ¼ inch per foot, is desired, with a minimum design slope of 1-½%. Water should be drained away from exterior columns/walls and pedestrian paths. Washes may be needed in slab corners to achieve drainage slopes.

Floor drain locations are determined by the circulation system, number of bays, and structural system. The top-level drain system should be designed to accept a 10-year design rainfall or as required by local code. Three to four-inch piping is generally used on covered levels.

Concrete-filled steel pipe bollards or bumper guards should be installed around all exposed piping, plumbing leaders, and exposed electrical conduit.

Fire Protection

- Fire protection design shall comply with NFPA 88A Standard for Parking Structures.
- Install dry standpipe system, where applicable.
- Coordinate location of Siamese fire department connection with local fire officials.
- Provide active fire suppression, mechanical ventilation, and a fire alarm system as required in sections of the parking structure that do not meet the requirements of open parking, in accordance with the referenced standard.
- Fire suppression systems in enclosed parking facilities should be located in a secure location.
- Preventative maintenance when needed and proper inspections should be conducted monthly.

PARKING STRUCTURE DESIGN GUIDELINES

Open or Enclosed Parking Structure

Natural ventilation requires openings in exterior walls of sufficient size distributed in such a way that fresh air will enter the facility to disperse and displace contaminated air. The 2015 International Building Code (IBC) states:

> *"For natural ventilation purposes, the exterior side of the structure shall have uniformly distributed openings on two or more sides. The area of such openings in exterior walls on a tier must be at least 20 percent of the total perimeter wall area of each tier. The aggregate length of the openings considered to be providing natural ventilation shall constitute a minimum of 40 percent of the perimeter of the tier. Interior walls shall be at least 20 percent open with uniformly distributed openings."*

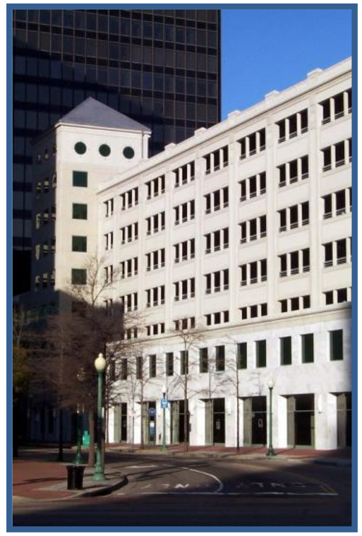
> *"Exception: Openings are not required to be distributed over 40 percent of the building perimeter where the required openings are uniformly distributed over two opposing sides of the building."*

Setbacks can affect openness as firewalls are required if certain distance requirements from property lines and other buildings are not maintained. Parking structures are typically classified as enclosed if other uses (retail, office, residential) are located above the parking but may remain open if parking is above or adjacent other uses. When a parking structure is positioned below grade, areaways can be used to achieve natural ventilation. The building code addresses the geometry required to permit acceptance of an areaway.

Parking structures classified as "open" do not require mechanical ventilation, fire suppression (sprinklers), and enclosed stairs.

"Enclosed"

- **Enclosed Shafts**
- **Mechanical ventilation**
- **Increased illumination**
- **Increased fire rating**
- **Fire sprinklers**



"Open"

- **"Open" structures are allowed much larger floor plates and many more levels**
- **"Open" structures are naturally ventilated, so do not usually need mechanical ventilation**
- **"Open" structures do not require stairs to be enclosed**
- **"Open" structures allow a lot of natural light**

Structural Systems

Following are the advantages and disadvantages of the three primary structural systems commonly used in parking structures today:

- ***Cast-in-Place Concrete***
- ***Precast Concrete***
- ***Steel Framed***

The selection of the structural system should be given careful consideration. The decision is often made based on the following:

- Owner preference
- Design team preference
- Development Review Agency (or Agencies) input
- Schedule
- Construction budget
- Openness and perceived headroom
- Owner's tolerance and budget for maintenance
- Local availability of product and labor

PARKING STRUCTURE DESIGN GUIDELINES

Cast-in-Place Concrete

Advantages of Cast-in-Place Construction:

- Monolithic construction so fewer sealant joints
- Positive drainage is easier to achieve
- Post-Tensioning forces reduces slab cracking
- Floor vibration imperceptible
- Flexible column spacing (20' to 27')
- Generally no shear walls
- Lower maintenance cost
- Wide beam spacing creates more open feeling with perception of higher ceiling
- Accommodates parking structures on irregular sites, beneath buildings, and underground

Disadvantages of Cast-in-Place Construction:

- Potentially higher construction cost
- Quality control is more difficult to attain due to exposed weather conditions
- May require architectural cladding to improve exterior aesthetics
- Less adaptable to winter construction in cold climates
- Longer on-site construction schedule
- Closer expansion joint spacing
- Congestion of tendons and rebar at beam column joints
- Larger on-site staging requirement

PARKING STRUCTURE DESIGN GUIDELINES

Precast Concrete

Advantages of Pre-Cast Construction:

- Quality control because members are fabricated at a plant
- Potentially lower construction cost in some regions
- Shorter on-site construction schedule
- Greater expansion joint spacing (up to 300 feet)
- More adaptable to winter construction
- Architectural façade spandrels also serve as structural load bearing elements

Disadvantages of Pre-Cast Construction:

- More propensity for leaking at the joints
- Higher maintenance cost for sealants
- The close spacing of thee tee stems creates the perception of lower ceiling height
- Tee stems can block signage and interfere with lighting distribution
- Shear walls affect architecture at the exterior and reduce visibility at the interior
- Reduced drainage slopes
- More bird roosting ledges
- Might not be performed by local subcontractors

PARKING STRUCTURE DESIGN GUIDELINES

Steel Framed

Advantages of Steel Construction:

- Flexible column spacing of 18' to 22'
- Generally no shear walls
- Can be performed by local subcontractors
- Shorter on-site construction schedule
- Potentially lower construction cost
- Easily accommodates vertical expansion

Disadvantages of Steel Construction:

- Erection concerns due to mixing foundation, steel, and precast subcontractors
- Not recommended where the steel is required to be fire rated by the building code
- Depending upon code requirements, steel structure may need to be fireproofed
- Steel painting for corrosion protection
- Maintenance of steel paint system
- Steel delivery times can fluctuate
- Extensive bird roosting ledges on the beam flanges

Durability Design

It is recommended to perform an analysis in the schematic design phase to determine which durability elements should be included in the design of a parking structure. These elements include sealers, deck coatings, concrete additives, corrosion inhibitors, and epoxy coated reinforcement. Traffic bearing elastomeric membranes should be installed, at minimum, on the top deck and over occupied spaces. Construction joints between elevated slab placements shall be tooled and sealed with a two-component polyurethane sealant on all floors where no membrane is applied. Self-leveling and non-sag sealants should be used where appropriate.

Durable parking structures also require quality concrete (low water-to-cement ratio), adequate concrete cover, proper concrete curing, and good drainage. Tradeoffs between initial costs and long-term maintenance costs should be considered. Enhanced durability systems should be provided in areas with severe exposure, such as supported structure near vehicular entries and snow storage areas on the roof level. Deck coatings (membrane) are recommended over occupied space and over electrical and storage rooms.

The design of a parking structure should at a minimum conform to the intent of American Concrete Institute's Guide for the Design of Durable Parking Structures (ACI 362). The design life of an open parking structure should be 60 years, anything longer is unrealistic unless it is a completely enclosed facility.

Maintenance

Proper preventative maintenance should be practiced to help ensure the longevity of the structure and cleanliness of the facility. Annual inspections should be conducted to assess the condition of the facility and need for repairs regarding cracks, spalls/delamination, deterioration, leaks, ponding, and safety issues.

The parking facility should include the following design features to support regular cleaning and maintenance:

- Mop sink,
- Hose bib for landscaping,
- Drain for mop water,
- Janitors closet, and
- Storage area.

A parking facility maintenance schedule should be established that outlines a schedule for the following items:

- Cleanings
- Trash pick-ups
- Power washing
- Snow removal and deicing
- Hardware review
- Electrical system review
- Security monitoring system review
- Heating ventilation and air conditioning system review
- Elevator check

- Landscaping
- Painting
- Plumbing system review
- Roofing and waterproofing review
- Signage review and
- Parking access and revenue control equipment check

For snow removal and deicing, care should be taken that these efforts do not harm the parking facility. Any deicing agents applied should not be destructive to the concrete and snow removal equipment should not harm coated membranes or concrete by using rubber blades. Light equipment such as bobcats and/or pick-up trucks should be used for snow removal and snow should not be piled against parapet walls. Roof level snow gates may be considered.

PARKING STRUCTURE DESIGN GUIDELINES

Incorporating Other Land Uses

Many cities today are encouraging or requiring the design of parking structures that enhance the urban environment. Design Guidelines have been established that require parking structures to have level façades on the street sides (no exposed ramps) and pedestrian-active uses on the ground level. Even if not required by local code, there has definitely been a trend away in recent years from stand-alone, single-purpose parking structures. The development of ground-floor retail space in parking structures is often encouraged as even second-rate retail space will typically generate more income per square foot than a good parking space. This is an important consideration as most new parking structures are not self supporting. When selecting a site for the development of a parking structure, the site that offers the best possibility for ground-floor retail space should be an important consideration.

- New parking structures should incorporate other land uses (e.g., first level commercial space or commercial/residential space wrapping one or more sides) whenever physically/financially possible.
- First level commercial space will increase first level floor-to-floor heights and may necessitate adjustments to the structure's ramping scheme (e.g., inclusion of non-parkable speed ramps).
- Designs should minimize the impact of commercial space on the first level circulation system.
- Designs may need to consider loading dock space and garbage space in the parking structure.

PARKING STRUCTURE DESIGN GUIDELINES

- Restaurant space will need adequate ventilation, which may impact parking efficiency on the levels above the space.

- Entry/exit locations should be adequately positioned to account for adjacent traffic patterns and roadway conditions. Entry/exits should provide for easy identification and access from adjacent streets.

- Parking demand for the integrated commercial/residential land uses should be included in the parking supply and demand analysis for the structure.

- If there is no current market for additional commercial space, the parking facility could be designed to accommodate additional land uses in the future when market conditions warrant.

Parking Structure Development Costs

Based on a review of several industry sources, including hundreds of completed parking structure projects of varying size, scope, and geographic location (omitting parking structures that are entirely below-grade because the cost of such structures is much higher), the national median construction cost for a new parking structure in 2017 is approximately \$19,000 – \$20,000 per space or \$56.99 – \$59.00 per square foot, increasing approximately 2.5% from 2015, when the median cost was approximately \$18,600 per space based on historical data.
Construction cost data does not include items such as land acquisition, architectural and engineering fees, environmental evaluations, materials testing, special inspections, geotechnical borings and recommendations, financing, owner administrative and legal, or other project soft costs. Soft costs are typically 15% to 20% of construction costs.

FEATURES TYPICALLY INCLUDED IN A MEDIAN COST PARKING STRUCTURE:

- Precast concrete superstructure
- Attractive precast concrete facade, but with basic reveal pattern
- Shallow spread footing foundations
- All above-grade construction
- 8’ 6” to 8’ 9” wide parking spaces
- Glass-backed elevators and unenclosed stairs clad with glass curtain wall to the exterior
- Basic wayfinding and signage
- Open parking structure with natural ventilation, without mechanical ventilation or fire sprinklers
- Little or no grade-level commercial space
- Basic parking access and revenue control system
- Energy efficient fluorescent lighting

PARKING STRUCTURE DESIGN GUIDELINES

ENHANCED DESIGN FEATURES THAT COULD INCREASE CONSTRUCTION COSTS ABOVE THE MEDIAN RANGE:

- Cast-in-place, post-tensioned concrete superstructure for lower maintenance
- Attractive facade with precast, brick, metal panels, and other materials
- 8' 9" to 9' 0" wide parking spaces for user comfort
- Green Garage Certification following the Green Parking Council standards
- Energy-efficient LED lighting with occupancy and photocell computer controls
- Custom wayfinding and signage system
- Storm water management including on-site retention/detention
- Deep foundations, such as caissons or pilings
- Below-grade construction
- Enclosed stair towers due to local code requirements
- Enclosed parking structure without natural ventilation, where mechanical ventilation and fire sprinklers are required • Grade-level commercial space
- Mixed-use development where the parking is integrated with office, retail, residential, or other uses
- State-of-the-art parking access and revenue control system
- License plate recognition systems
- Parking guidance systems
- Count system with variable message LED signs
- Pay-on-foot parking revenue control stations
- Wi-Fi and cellular services

FACTORS AFFECTING PARKING STRUCTURE COSTS

People often think of parking structure development costs primarily in terms of dollars per space, however, there are many other factors that should be considered. The cost of a parking space is a product of parking efficiency (SF per space) and structure efficiency (dollars per square foot). Each component plays a critical role in determining the ultimate cost of a parking facility. Parking efficiency is the total gross area of a parking structure, inclusive of stairs, elevators, and all parking floors, divided by the number of spaces. Typical parking efficiency for an above ground, stand-alone garage is 310 to 350 SF per space. Many below-grade or mixed-use garages can have parking efficiencies of 400 to 500 SF per space. Factors affecting parking structure development costs include:

- **Geography.** Construction costs vary by location due to regional factors such as the cost of labor and availability of materials. In addition, factors such as higher seismic regions and soil conditions have a large impact on cost.
- **Number of Parking Levels.** In general, a larger-footprint parking structure with fewer levels will cost less per parking space than a taller structure with a smaller footprint. The cost per square foot of the first level at-grade is less than levels elevated above the ground. A lower-height, larger-footprint structure will have a higher proportion of the cost in the first level. Taller structures are heavier which affects the foundation cost. A taller structure generally has a less efficient parking layout, which translates into more square footage for each parking space.
- **Parking Below-grade.** Parking below-grade is much more expensive than parking above-grade. A five-level, above grade parking structure may cost $50 per square foot. If this same

structure is depressed one level below-grade, the cost can increase approximately 15% to $57.50 per square foot. If the same structure is put two levels below ground, the cost increases even more because of the impacts of having to dig deeper (45% higher than the original cost or approximately $72 per square foot).

- **Structural System.** 60% to 70% of parking costs are in the structural system. As such, the type of framing system will have a significant effect on the cost of each parking space. There are two general types of framing layouts—short-span and long-span. Short span requires a column approximately every three parking spaces (27x30 feet square) to support the floor slab. Long span requires columns spaced 60 feet apart, with beams spanning over the stalls and drive aisle. Generally, short-span systems cost less per square foot, but negatively effects efficiency. Long-span systems cost more per square foot but results in more stalls in the same square footage.

  The structural system can be cast-in-place concrete, precast concrete, or structural steel. The most cost-effective option depends on the project's location and the region's preferred construction methods. The selection of a system not common in the area will generally cause the cost to increase.
- **Foundation.** Structures built in areas with poor soil conditions requiring more expensive, deeper foundation systems will cost more. The difference between a shallow and deep foundation system can increase the price approximately 10% overall—taking the cost from $50 to $55 per square foot, for example.
- **Architectural Facade Treatment.**

  The appearance of a parking structure is important to the surrounding environment. The cost of making that structure more aesthetically-pleasing can affect the cost per parking space of up to 15%. If the structural system is used to create the architectural facade, the cost per square foot will be less. However, the use of architectural elements in addition to the structural system will increase the cost. If the architectural design creates an inefficient structural system, the cost could increase drastically.

- **Total Parking Spaces.** A smaller project will cost more per space than a larger project. A 200-space parking structure on a small site may cost about 30% more per square foot than a 1,000-stall structure on a reasonably sized lot.
- **Parking Efficiency.** The cost of a parking space is the cost per square foot multiplied by the square foot per space. The more square footage per stall, the higher the cost.

Example:

– Typical efficiencies for short-span structures:	330-390 sf/stall
– Typical efficiencies for long-span structures:	300-340 sf/stall
– Typical efficiencies for mixed-use structures:	400+ sf/stall

Example:

Assume a 500-space structure costs $50 per square foot:

330 sf/stall * 500 stalls = 165,000 sf * $50/sf = $8,250,000

360 sf/stall * 500 stalls = 180,000 sf * $50/sf = $9,000,000

The difference is $750,000, or $1,500 per stall.

- **Premium Elements.** Program elements added to parking will increase the cost per stall. A photovoltaic system covering 50% of the top level can add approximately 25-30% to the building's cost per square foot of the building. However, there may be operational cost savings that can support this type of elements. A mixed-use component will also increase the cost per stall due to negative impacts on efficiency and the structural framing system. Special site conditions such as the need to reroute utility lines or perform substantial demolition may increase cost as well.

- **Market Conditions.** The cost of parking can be negatively and positively affected by market conditions by 10% or more. A normal bid market will generate four to six bids from qualified contractors. An aggressive bid market might see 10 or more bids, causing the price to decrease. This can also create concern if the bidders are not qualified. An impacted bid market might see one to three bidders and a price increase due to lack of competition.

In the end, most owners budget for parking in terms of dollars per space. To be as accurate as possible, it is best to understand the project in terms of parking efficiency as well as structural efficiency. Design decisions that enhance efficiency can often help make a project more financially feasible.

Sources:

1. Fixr, Build a Parking Garage Cost (https://www.fixr.com/costs/build-parking-garage)
   Note: FIXR estimates a $59 per square foot cost, though their estimate of the national average stands between $50 to $70 for most projects.
2. International Parking Institute, "How Much Does a Structure Cost?" H. Dean Penny, Kimley-Horn
3. Victoria Transport Policy Institute, "Parking Costs" (www.VTPI.org)
4. Carl Walker, Inc., "Parking Structure Cost Outlook" (www.carlwalker.com)
5. Parking Today, "The Top 10 Issues Affecting the Cost of Building a Parking Space" by Watry Design

Other Considerations

There are other aspects of parking structure design that will not be specifically addressed but should be kept in mind, including:

- Zoning Requirements (permitted uses, setbacks, easements, etc.)
- Building Code Compliance
- Subsurface Conditions and Foundations
- Aesthetics
- Fire Rating, Fire Protection and Life Safety
- Mechanical Systems
- Storm Drainage and Water Storage
- Parking Access and Revenue Control Equipment
- Impact of Mixed Uses (retail, residential and office)
- Parking Office Requirements

The parking facility should meet or exceed all applicable codes regarding the elevator, plumbing, electrical, lighting, mechanical, building design, ADA, signage, and material standards.